

WHAT IS CLAIMED IS:

1. A safety controller comprising:

a basic module;

one or more extension modules; and

a mother board provided with an extension slot for connecting the modules by a bus; wherein

an input extension module which is one of the extension modules includes one or more input terminal sections capable of connecting one or more safety switches and an input circuit for receiving safety input signals from one or more external input terminal sections,

an output extension module which is one of the extension modules includes an external output terminal section which can be connected to an output control system of a dangerous source and an output circuit for transmitting a safety output signal to an external output terminal section, and

the basic module has operation program storing part for storing a safety operation program for defining the relation between the state of a safety input signal and the state of a safety output signal on each of types of predetermined safety switches, type-of-switch setting part for setting an external input terminal section and the type of a safety switch to be connected to the external input terminal section, operation program

executing part for selecting a safety operation program corresponding to the type of the switch set by the setting part among a plurality of safety operation programs stored in the operation program storing part and executing the program for the external input terminal section set by the setting part.

2. The safety controller according to claim 1, wherein the basic module also includes;

one or more external input terminal sections capable of connecting one or more safety switches,

an input circuit for receiving safety input signals from one or more external input terminal sections,

an external output terminal section which can be connected to an output control system of a dangerous source, and

an output circuit for transmitting a safety output signal to the external output terminal section.

3. The safety controller according to claim 1, wherein

the basic module includes part for executing a diagnostic program for diagnosing whether a predetermined extension module is set to each extension slot by collating the module identifying information read from an extension slot on a mother board with the module identifying information set to the basic module.

4. The safety controller according to claim 1,  
wherein the basic module is further provided with;

troubleshooting-program storing part which stores a  
troubleshooting program for troubleshooting a safety  
switch connected to an external connection terminal  
section every type of safety switch, and

troubleshooting-program executing part which selects  
a troubleshooting program corresponding to the type of a  
switch set by setting part among a plurality of types of  
troubleshooting programs stored in the troubleshooting-  
program storing part, and executes the selected program  
for an external input terminal section set by the setting  
part.

5. The safety controller according to claim 4,  
wherein

the troubleshooting program of an electromagnetic-  
locking door switch having an unlocking solenoid includes  
a solenoid diagnosing function for troubleshooting the  
unlocking solenoid.

6. The safety controller according to claim 4,  
wherein

a troubleshooting program includes a history  
generating function for making it possible to diagnose  
the contact deterioration of a safety switch in  
accordance with aging of the time difference between

signals of two systems coming from a pair of interlocking contacts included in a safety switch.

7. The safety controller according to claim 4, wherein

a troubleshooting program includes a history generating function for making it possible to diagnose the contact deterioration of a contactor in accordance with aging of the time difference until a feedback signal comes from a contactor auxiliary contact after transmitting a safety output signal.

8. The safety controller according to claim 1, wherein

the basic module includes part for executing an output monitoring program for monitoring the state of a contactor constituting the output control system of a dangerous source in accordance with a contactor auxiliary-contact signal received from a feedback input terminal set to the basic module or an extension module.

9. The safety controller according to claim 1, wherein

the basic module includes part for executing an interlocking program for controlling the propriety of an output operation which is an execution result of the safety operation program in accordance with a PLC operation state signal received from a PLC operation

state input terminal set to the basic module or an extension module.

10. A safety system comprising the safety controller of claim 1 and one or more safety switches connected to the safety controller.

11. The safety controller according to claim 1, wherein

an emergency stop switch is included as a predetermined type of safety switch, and

a safety operation program corresponding to the emergency stop switch executes;

a first step of detecting a short circuit, disconnection, or discontinuity of each system by supplying output signals of two systems having on- and off-signals to the external terminal section of an input expansion module whose set switch type is an emergency stop switch through the bus connection, capturing input signals of two systems from emergency stop switches corresponding to the output signals respectively through a break contact, and confirming whether the input signals correspond to the output signals respectively and on- and off-signals can be obtained,

a second step of detecting a disconnection or discontinuity in either of input circuits of two systems by supplying an on-signal to each of input circuits of

two systems for capturing the input signals of two systems, confirming whether on-signals can be obtained from the input circuits and/or supplying an off-signal to the input circuits, and confirming whether off-signals can be obtained from the input circuits, and

a third step of confirming that a short circuit does not occur between two systems by outputting on- and off-signals to the output signals of two systems at timings reverse to each other, capturing input signals kept in the corresponding relation reverse to the corresponding relation in the first step, and

a fourth step of transmitting a safety output signal to the external output terminal of the output expansion module through the bus connection and the output circuit when at least either of the two systems becomes a discontinuity in the first step, a disconnection or discontinuity occurs at least either of the two systems in the second step, or a short circuit occurs between the two systems in the third step.

12. The safety controller according to claim 1, wherein

a mat switch is included as a predetermined type of safety switch, and

a safety operation program corresponding to the mat switch executes;

a fifth step of detecting a continuity, disconnection, or erroneous wiring of each system by supplying output signals of two systems having on- and off-signals to the external input terminal section of an input expansion module whose set switch type is the mat switch through the bus connection at the timing in which the signals of two systems are not overlapped each other, capturing input signals of two system from mat switches corresponding to output signals respectively, and confirming whether on- and off-signals can be obtained correspondingly to the output signals,

a sixth step of detecting a disconnection or discontinuity in either of input circuits of two systems by supplying an on-signal to input circuits of two systems for capturing the input signals of two systems, confirming whether on-signals can be obtained from the input circuits and/or supplying an off-signal to an input circuit, and confirming whether off-signals can be obtained from the input circuit,

a seventh step of detecting a continuity or discontinuity between two systems by outputting on- and off-signals to the output signals of two systems at timings reverse to each other, capturing input signals kept in the corresponding relation reverse to the corresponding relation in the first step, and confirming

that the supplied on-output signals are not obtained as input signals, and

an eighth step of transmitting a safety output signal to the external output terminal of the output expansion module through the bus connection and the output circuit when at least either of the two systems detects a disconnection or erroneous wiring in the fifth step, a disconnection or discontinuity occurs in at least either of input circuits of two systems in the sixth step, or a discontinuity occurs between the two systems in the seventh step.

13. The safety controller according to claim 1, wherein

a two-hand-control switch is included as a predetermined type of safety switch, and

a safety operation program corresponding to the two-hand-control switch executes;

a ninth step of detecting that the two-hand-control switch is correctly operated by supplying output signals of two systems which are on-signals to the external input terminal of an input expansion module whose set switch type is a two-hand-control switch through the bus connection, capturing input signals of two systems through make contacts of two-hand-control switches corresponding to the output signals respectively, and



confirming whether the input signals of two systems are turned on within a predetermined time,

a tenth step of detecting a disconnection or discontinuity in input circuits of two systems for capturing the input signals of two systems by supplying an on-signal to the input circuits, confirming whether on-signals can be obtained from the input circuits and/or supplying an off-signal to the input circuits, and confirming whether the off-signal can be obtained from the input circuits, and

an eleventh step of confirming that a short circuit does not occur between two systems by outputting on- and off-signals to the output signals of two systems at timings reverse to each other, capturing input signals kept in the corresponding relation reverse to the corresponding relation in the first step, and confirming that the supplied on-signals are not obtained as input signals, and

a twelfth step of transmitting a safety output signal to the external output terminal of the output expansion module through the bus connection and the output circuit when it is detected that the two-hand-control switch is correctly operated in the ninth step, a disconnection or discontinuity occurs in either of the circuits of two systems in the tenth step, or a short

circuit occurs between the two systems in the eleventh step.

14. The safety controller according to claim 1, wherein

a light curtain is included as a predetermined type of safety switch, and

a safety operation program corresponding to the light curtain executes;

a thirteenth step of detecting that the light curtain is interrupted from light when input signals of two systems sent from the light curtain are captured from the external input terminal of an input expansion module whose set switch type is the light curtain through the bus connection to obtain an off-signal,

a fourteenth step of detecting a disconnection or discontinuity in input circuits of two systems by supplying an on-signal to input circuits of two systems for capturing the input signals of two systems, confirming whether on-signals can be obtained from the input circuits and/or supplying an off-signal to an input circuit, and confirming whether off-signals can be obtained from the input circuits, and

a fifteenth step of transmitting a safety output signal to the external output terminal of the output expansion module through the bus connection and the

output circuit when the light interrupted state of the light curtain is detected by detecting an off-signal by at least either of the two systems in the thirteenth step or a disconnection or discontinuity occurs in either of the input circuits of two systems in the fourteenth step.